CHAPTER 7
Fisheries

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There are two key aquatic environments that support fish in the Lake Tahoe Basin, lakes and streams. These two ecosystems are dynamic and characteristically change in space and time. Combined, lakes and streams provide fish with necessary elements such as water, cover, and spawning and nursery habitat. Both environments play an important role in sustaining fish populations and cannot be viewed independently because some fish species use both lake and stream environments to fulfill their life cycles. The combination of chemical, biological, temperature, and physical characteristics of lakes and streams influence the suitability of these environments to sustain different fish populations. Likewise, the physical and biological integrity of the surrounding landscape plays an important role in sustaining aquatic habitats important to fish. Accordingly, degradation of lake and stream habitat, and the surrounding landscape can reduce the sustainability of Tahoe's fishery.

The diversity (species richness and abundance) of Lake Tahoe's fish community has changed considerably since the settlement of Euro-Americans to the Lake Tahoe Basin. Prior to the influence of Euro-American settlement, seven species of fish occurred in the lakes and streams of the Lake Tahoe Region (USDA 2000; Ngai et al. 2011). Of the native fish species, Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) and the mountain whitefish (*Prosopium williamsoni*) were abundant and revered by Native Americans because they provided ample food for their people. Since the Comstock era (circa 1860), Lahontan cutthroat trout were extirpated, mountain whitefish populations have declined substantially, and at least 20 additional species of fish have been introduced into Lake Tahoe's aquatic communities (USDA 2000, Ngai et al. 2011). Fisheries biologists have deduced that several factors have contributed to the alteration of Tahoe's fish species diversity, the decline or extirpation of native fish, and the degradation of aquatic habitats in the Region. These factors include sedimentation associated with turn of the century logging, livestock grazing, commercial fish harvests, interruption of natural hydrologic regimes resulting from past logging practices, urban development (1950s through 1970s), and the introduction of non-native fish and other aquatic organisms (SNEP 1996, USDA 2000, Ngai et al. 2011). Today, stream restoration and efforts to reintroduce Lahontan cutthroat trout are underway (Al-Chokhachy et al. 2009).

The *Regional Plan*, including the *Goals and Policies (TRPA 1986)* and the *Code of Ordinances (Code) and Rules of Procedure (TRPA 1987a as amended in 2012)*, provide relevant policies and regulations for the maintenance of habitat conditions for Fisheries Threshold Standards. The Environmental Improvement Program (EIP), administered by TRPA, includes programs that result in the enhancement or restoration of fish habitats in the Region. For example, EIP projects that reestablish the natural hydrologic regimes, remove impervious cover and enhance vegetation cover in stream zones are

widely understood to enhance the quality of stream habitat for various species of fish and aquatic organisms. In addition, erosion control and stormwater treatment projects implemented through the EIP improve water quality and thus improve habitat quality for Tahoe's fishery.

According to the Goals and Policies for Fisheries, there is one goal and nine Policy Statements relevant to maintaining fisheries resources.

The nine policies include:

1. Mitigating project impacts to fish habitat in streams and lakes
2. Prohibiting the development of blockages and other impediment to fish movement in streams
3. Developing an in-stream maintenance program to inventory and remove stream blockages
4. Establishing boating standards to reduce associated disturbance in Lake's shallow zone
5. Encouraging habitat improvement projects in streams and lakes
6. Maintaining and enhancing instream flows
7. Transferring existing points of water diversion from streams to the Lake, whenever feasible
8. Supporting state and federal efforts to reintroduce Lahontan cutthroat trout
9. Controlling the level of Lake Tahoe to reflect seasonal weather and runoff patterns

The core of TRPA's fisheries regulations designed to achieve Threshold Standards is detailed in *TRPA Code of Ordinances, Chapter 64*, and applicable regulations for the management of fish habitats can be found throughout the *Code of Ordinances (TRPA 1987a as amended in 2012).* For example, *Code of Ordinances, Chapter 53,* restricts urban development within stream environment zones. *Code of Ordinances, Chapter 64,* includes provisions that protect fish habitat and enhance degraded lake and stream habitat. For lake environments, all projects and activities conducted in the shorezone may be prohibited, limited, or otherwise regulated in prime habitat areas (spawning, feed and cover habitats that include submerged substrates comprised of gravels, cobbles, and rocks), or in situations that TRPA found to be vulnerable or critical to the needs of fish. Special conditions of project approval, such as restoring physically altered substrate, limiting construction to designated periods, or implementing shoreline protective measures, may be required for development in the shorezone to mitigate or avoid significant adverse impacts to habitat or fish. Certain activities, such as boat beaching, may be temporarily restricted in areas where spawning activity occurs. To support the nondegradation standard that applies to lake fish habitat, TRPA's Code prohibits the alteration of substrate in areas of prime fish habitat unless mitigated and approved by TRPA. The protection provision for instream habitats is similar; prohibit stream channel alterations, stream crossings shall be designed to facilitate fish movement, barriers to fish movement are permitted to be removed, development shall fully mitigate impacts to fish habitat, maintain instream flows, prevent sediment entry into streams, and provide vegetative cover. More recently, the agency adopted additional ordinances to prevent the introduction of new aquatic invasive species by requiring inspections and possible decontaminations of all boats entering regional lakes.

The goal of TRPA adopted Threshold Standards for the fisheries resources is to improve aquatic habitat important for the growth, reproduction, and perpetuation of existing and threatened fish resources in the Lake Tahoe Basin (TRPA 1982a). TRPA has adopted one Numerical Standard (stream habitat condition), one Management Standard without a numeric target (instream flow), one Management Standard with a numeric target (lake habitat) and two Policy Statements (instream flow and Lahontan cutthroat trout) (Table 7-1). There are four Indicator Reporting Categories included in the Fisheries Threshold Category, including 1) lake habitat, 2) stream habitat, 3) instream flow, and 4) Lahontan cutthroat trout.

Table 7-1: *Summary of Fisheries Indicator Reporting Categories, adopted TRPA Threshold Standards by type, and indicators used to assess adopted standards.*

Indicator Reporting Category	Standard	Type of Standard	Indicator
Lake Habitat	A nondegradation standard shall apply to fish habitat in Lake Tahoe. Achieve the equivalent of 5,948 total acres of excellent habitat [§]as indicated by the Prime Fish Habitat Overlay Map dated 5/19/97 as may be amended from time to time.	Management Standard (w/ numeric target)	Acres of fish habitat within the nearshore of Lake Tahoe - defined by substrate size
Stream Habitat	Maintain the 75 miles of excellent, 105 miles of good, and 38 miles of marginal stream habitat as indicated by the Stream Habitat Quality Overlay map, amended May 1997, based upon the re-rated stream scores set forth in Appendix C-1 of the 1996 Evaluation Report.	Numerical Standard	Miles of stream habitat in different condition classes (excellent, good and poor)
Instream Flow	Until instream flow standards are established in the Regional Plan to protect fishery values, a nondegradation standard shall apply to instream flows.	Management Standard	Evidence of TRPA support for Management Standard
	It shall be a policy of the TRPA Governing Board to seek transfers of existing points of water diversion from streams to Lake Tahoe.	Policy Statement	Evidence of TRPA support for policy statement
Lahontan Cutthroat Trout	It shall be the policy of the TRPA Governing Board to support, in response to justifiable evidence, state and federal efforts to reintroduce Lahontan cutthroat trout.	Policy Statement	Evidence of TRPA support for policy statement

Lake Habitat

There is one Threshold Standard associated with the Lake Habitat Indicator Reporting Category. The Lake Habitat Threshold Standard is listed as a Management Standard with a numeric target to achieve the equivalent of 5,948 acres of "prime" fish habitat. Prime fish habitat includes spawning habitat, and feed and cover habitat. Spawning habitats are composed of relatively small diameter gravel substrates used by native minnows for spawning and rearing fry. Feed and cover habitats are composed of larger diameter cobbles, rocks, and boulders, used by fish as foraging habitat, and to provide refuge from predation. "Marginal" habitats are dominated by sand and silt substrates interspersed with occasional willow thickets that establish during low lake levels.

According to TRPA (1982a), "*The quality of the lake can be evaluated and tested against the threshold using measures of habitat disturbance and substrate conditions.*" An indicator for the Lake Habitat Threshold Standard was identified in TRPA (1996) as "Physical disturbance of rocky substrate (acres)." TRPA (1982a) considered moderate to heavy boat traffic as a disturbance that significantly contributed to the decline of lake fish habitat quality. TRPA's Threshold Evaluation (1996) further determined that the rearrangement or clearing of near shore substrate (to accommodate beach use during low Lake levels) degraded fish habitat conditions. Since the initial adoption of the Threshold Standard, studies have revealed that boat activity is not sufficiently frequent in the littoral zone to degrade conditions in "prime" fish habitat (Allen and Reuter 1996). In the 2006 Threshold Evaluation, TRPA instead measured and reported on the extent and distribution of rocky substrates ("prime" fish habitat in the littoral zone) because of the challenges associated with defining and measuring "disturbed rocky substrates." This approach more directly addressed whether the management target of 5,958 acres was achieved.

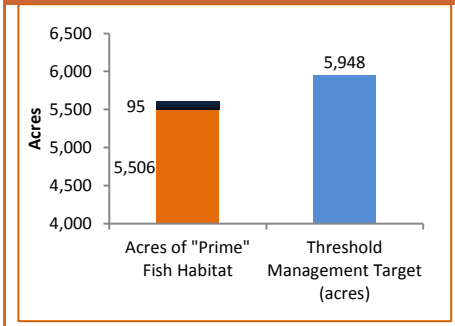
The status and trends of one indicator related to the Management Standard (with a numeric target) for Lake Habitat was evaluated to characterize the overall status and trend of the Lake Habitat Indicator Reporting Category. The indicator for Lake Habitat showed that the status is "at or somewhat better" than adopted management targets with an "unknown" trend. Overall confidence in the determination of status and trend is "low" due to the low confidence in trend and the fact that fish habitats have not been remapped since 2002. Other indicators related to biological and chemical parameters should be measured to better characterize the status and trends of littoral Lake Habitat conditions. Evidence from current research (Ngai et al. 2011) suggests that nearshore fish habitat conditions have declined. However, these changes to the Lake Tahoe fishery are not detectable using the indicator associated with the currently adopted Lake Habitat Threshold Standard. The management provisions embodied in the Lake Habitat Threshold Standard have been incorporated into the *Regional Plan* and are implemented through the TRPA permit review process.

Lake Habitat: **Acres of "Prime" Fish Habitat**

Reporting Icon

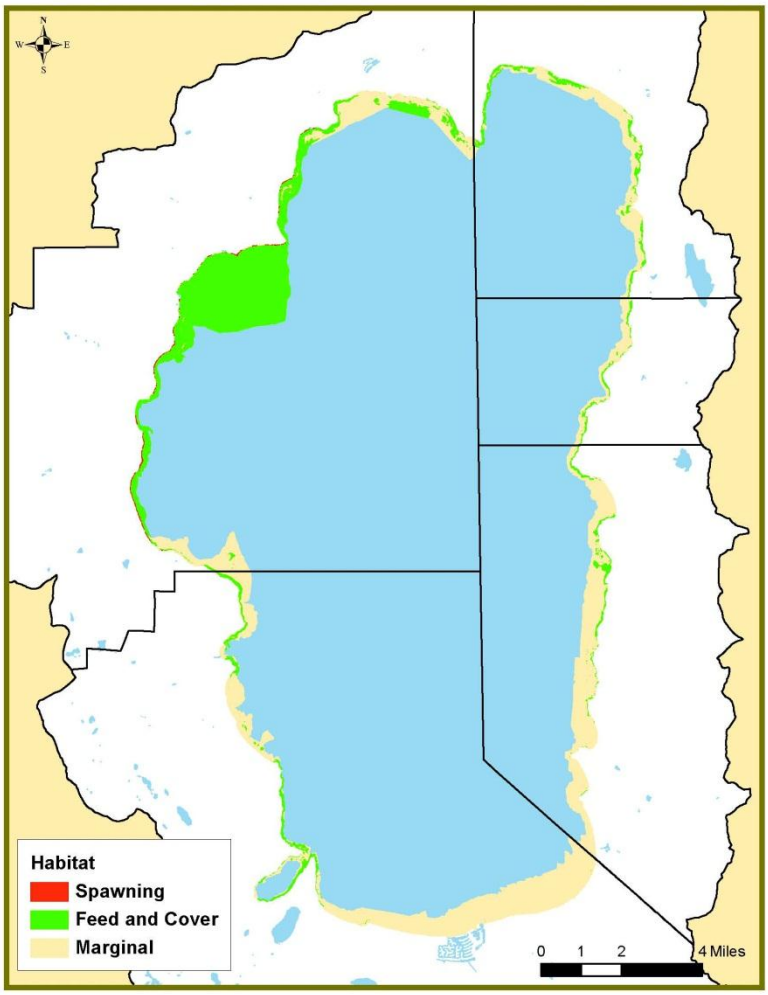
ACRES OF "PRIME" FISH HABITAT
Status: **At or Somewhat Better than Target**
Trend: **Unknown - Insufficient Data**
Confidence: **Low**

Graph



Recent aerial extent of "prime" fish habitat (spawning habitat - dark blue, feed and cover habitat - orange) relative to TRPA's Lake Habitat Management Standard (red) as characterized by Metz and Herold (2004) and Herold et al. (2007). Error in habitat acreage estimates was ± 14%, indicating no statistical difference between the aerial extent of prime fish habitat and the adopted management target.

Map



Distribution and extent of different nearshore lake habitats in Lake Tahoe (Metz and Herold 2004; Herold et al. 2007).

Data Evaluation and Interpretation

Relevance – This indicator measures the aerial extent (acres) of rocky substrates in Lake Tahoe's nearshore (i.e., littoral zone) known as "prime" fish habitat. Different diameter rock substrates are used by Lake Tahoe's fish community to fulfill different life history requirements. Substrates composed primarily of rocks smaller than 64mm and larger than 2mm in diameter (gravels) are used for spawning by native minnow species, while substrates primarily composed of larger diameter rocks (cobble, rocks, boulders) are used for foraging and for cover by a variety of fish species (Beauchamp et al. 1994a). Spawning, and feed and cover substrates together comprise "prime" fish habitat. TRPA's Lake habitat standard aims to prevent the loss of "prime" fish habitats as a result of shorezone development. This indicator does not measure the abundance of different fish species or the community composition or trophic structure of Lake Tahoe littoral zone.

Threshold Category –Fisheries

Indicator Reporting Category – Lake Habitat

Adopted Standards – A nondegradation standard shall apply to fish habitat in Lake Tahoe. Achieve the equivalent of 5,948 total acres of excellent habitat as indicated by the Prime Fish Habitat Overlay Map dated 5/19/97.

Type of Standard - Management Standard (with a numeric target)

Indicator (unit of measure) – Acres of rocky (spawning and feed/cover habitats) substrates ("prime" fish habitat - acres)

Status – Based on remotely sensed (IKONOS) data collected and analyzed from 2002 (Metz and Herold 2004; Herold et al 2007) there are about 5,602 acres of "prime" fish habitat in Lake Tahoe's littoral zone, suggesting that the Region has reached approximately 94% of the management target of 5,948 acres. However, given that the accuracy of the "prime" fish habitat map based on 2002 data was 86%, there is no statistical difference in the extent of fish habitat reported by Metz and Herold (2004) and Herold et al. (2007) and the management target, because more current acreage estimates are within the identified mapping error of ± 14%. Since 1989, construction within Lake Tahoe's littoral zones has been regulated by TRPA. TRPA has not permitted the unmitigated construction of piers, boat launches and other developments that would degrade or disturb the littoral substrate. In addition, efforts to restore "prime" habitat have not occurred since 2002. Consequently, there were likely no substantial changes in the extent of fish habitat since 2002, other than changes that may have occurred as a result of natural littoral drift and fluctuating Lake levels. As revealed in the 2006 Threshold Evaluation and by others (Kamerath et al. 2008; Ngai et al. 2011), additional factors are likely affecting the quality of littoral habitats, such as the introduction and expansion of aquatic invasive species. Ngai et al. (2011) found that there has been a significant reduction in minnow species abundance and distribution in Lake Tahoe's nearshore. Recent studies have identified more meaningful indicators of fish habitat conditions (Ngai et al. 2011) and additional synthesis of nearshore research is nearing completion (Heyveart, personal communication, 2011). Completion of these studies was identified as an interim target in the 2006 Threshold Evaluation.

Trend – The trend determination in the aerial extent of "prime" fish habitat is "unknown" due to differences in the mapping approach used to establish the management target (TRPA 1982a), and the mapping approach used by Metz and Herold (2004) and Herold et al (2007). Also, more current mapping efforts have not been conducted since the 2002 source data to establish current day conditions. Multispectral imagery data were collected in 2010. If funding were provided, fish habitats could be remapped using new data, if it is found to be an appropriate investigation (given identified shortcomings of characterizing the actual condition of fish habitat and fish population status). Ngai et al. (2011) reported that from 1991-1994 and 2008-2009, the predominant fish species caught in the nearshore minnow traps were Lahontan redside shiners (*Richardsonius egregius*) and speckled dace (*Rhinichthys osculus robustus*). However, current catch of these and other species have declined. Overall, nearshore fish densities decreased (58 % of historically sampled sites) between 1988-1989, and 2009. In particular, Lahontan redside shiner densities have declined (25-100%) at 42% of the historically sampled sites. No significant change in speckled dace summer body condition was observed between 1994 and 2008-2009. Lahontan redside shiners' summer body condition was poorer in recent years than in 1994 (Ngai 2011). Tahoe suckers' fall body condition in 2008 increased when compared to habitat conditions in 1994. Lahontan reside shiners are consuming a wider range of food types and relying more on surface food sources than before (Ngai et al 2011). These changes may be due to nearshore habitat modifications, food availability, or water clarity. Predation from non-native game fish (e.g. lake trout) may also contribute to the decline when native fishes move offshore in the winter. Changes in spawning activities (spawning behavior and egg presence) and condition of spawning habitats (substrate types) were observed in 30% (6/20) of the sites when compared to historical data collected by Allen and Reuter (1996). Changes observed can potentially be attributed to the availability of substrate types at various spawning sites as a result of fluctuations in Lake water levels.

Confidence

Status – According to Metz and Herold (2004) and Herold et al. (2007), the fish habitat map used to characterize Lake Tahoe fish habitat was 86% accurate. However, Lake habitats have not been remapped to represent current day conditions. Because of this, the current status determination is "low."

Trend – The confidence in the trend for "prime" fish habitat is "low" due to differences in mapping approaches and lack of

current fish habitat data. Recent research suggests high confidence in the reduction of native minnow abundance and distribution because the same sites were sampled in previous efforts.

Overall – Overall, confidence in the status and trend determination is "low" because of the low confidence in trend information, and because Lake habitats have not been remapped since 2002.

Interim Target – Due to insufficient trend information and no foreseeable in-Lake habitat restoration projects, an interim target is to maintain 5,601 acres of "prime" fish habitat (the estimate reported by Metz and Herold in 2004). The current aerial extent of "prime" fish habitat suggests the Region is meeting adopted management targets.

Target Attainment Date – Based on the most recent estimates of Lake habitat acreages, the Region is in attainment with the adopted management target and thus it is not necessary to identify a target attainment date.

Human and Environmental Drivers – The physical removal, rearrangement, or covering of littoral zone substrates can influence the status of this indicator. Fluctuations in Lake level can also significantly affect the availability of "prime" fish habitat, especially spawning habitat (Allen and Reuter 1996; Metz and Herold 2004). Urbanization along the shorezone, recreational activities (trampling by beach-goers), excessive fish harvest (e.g., minnow trapping), excessive nutrients, increased water temperature associated global climate change, and non-native fish and other non-native aquatic organisms (e.g., invasive aquatic weeds) are all factors that can influence the overall quality of Lake Tahoe's fish habitat and fish species composition (Ngai et al. 2011).

Monitoring Partners – UC Davis, University of Nevada, Reno, California Department of Fish and Game, Nevada Department of Wildlife, and TRPA

Monitoring Approach – Methods used to describe fish habitat distribution and extent presented in this evaluation (and in the 2006 Threshold Evaluation) can be found in Metz and Herold (2004) and Herold et al. (2007). In summary, multispectral imagery (IKONOS) acquired in July 2002 was interpreted and validated to reveal the aerial extent (acres) of different substrate types within Lake Tahoe littoral zone.

Programs and Actions Implemented to Improve Conditions – TRPA regulates projects and activities in the shorezone and littoral zone of Lake Tahoe that may result in fish habitat loss or degradation. TRPA collects fish habitat mitigation fees for projects that result in substrate disturbance of prime fish habitat. Fees are reserved for fish habitat restoration projects. Further measures that provide benefits to fish habitat are found in TRPA Goals and Polices (TRPA 1986), and Code of Ordinances (TRPA 1987a as amended in 2012), as well as other state and federal laws.

Effectiveness of Programs and Actions – The current policies and ordinances seems appropriate due to their emphasis on the protection of fish habitat. However, restoration efforts to increase acreage of suitable substrate are lacking and available funds from the mitigation fee program are insufficient to support meaningful on-the-ground restoration projects. The current standard and associated indicator for Lake habitat are antiquated because they only measure one physical dimension of the littoral zone. Other dimensions (chemical and biological) of fish habitat should be measured, evaluated, and reported to provide a more complete assessment of fish habitat conditions in Lake Tahoe. Recent studies (funded through the Southern Nevada Public Lands Management Act) on Lake Tahoe's nearshore indicators will assist in informing amendments to the Lake Habitat Threshold Standard.

Recommendation for Additional Actions – Continue to emphasize the control and prevention of aquatic invasive species as it is suspected that their presence threatens the biological integrity of Lake Tahoe's littoral fish habitats (Kamerath et al. 2008; Ngai et al. 2011). The current indicator only measures one dimension of fish habitat condition. It is recommended that the results of new scientific information on Lake Tahoe's nearshore be incorporated into an updated Lake Habitat Threshold Standard. If increasing acreage of prime fish habitat continues to be a focus of the Lake Habitat Threshold Standard, efforts are needed to identify and implement restoration of spawning habitats (gravel substrates) considering these substrate types are the most limited.

Stream Habitat

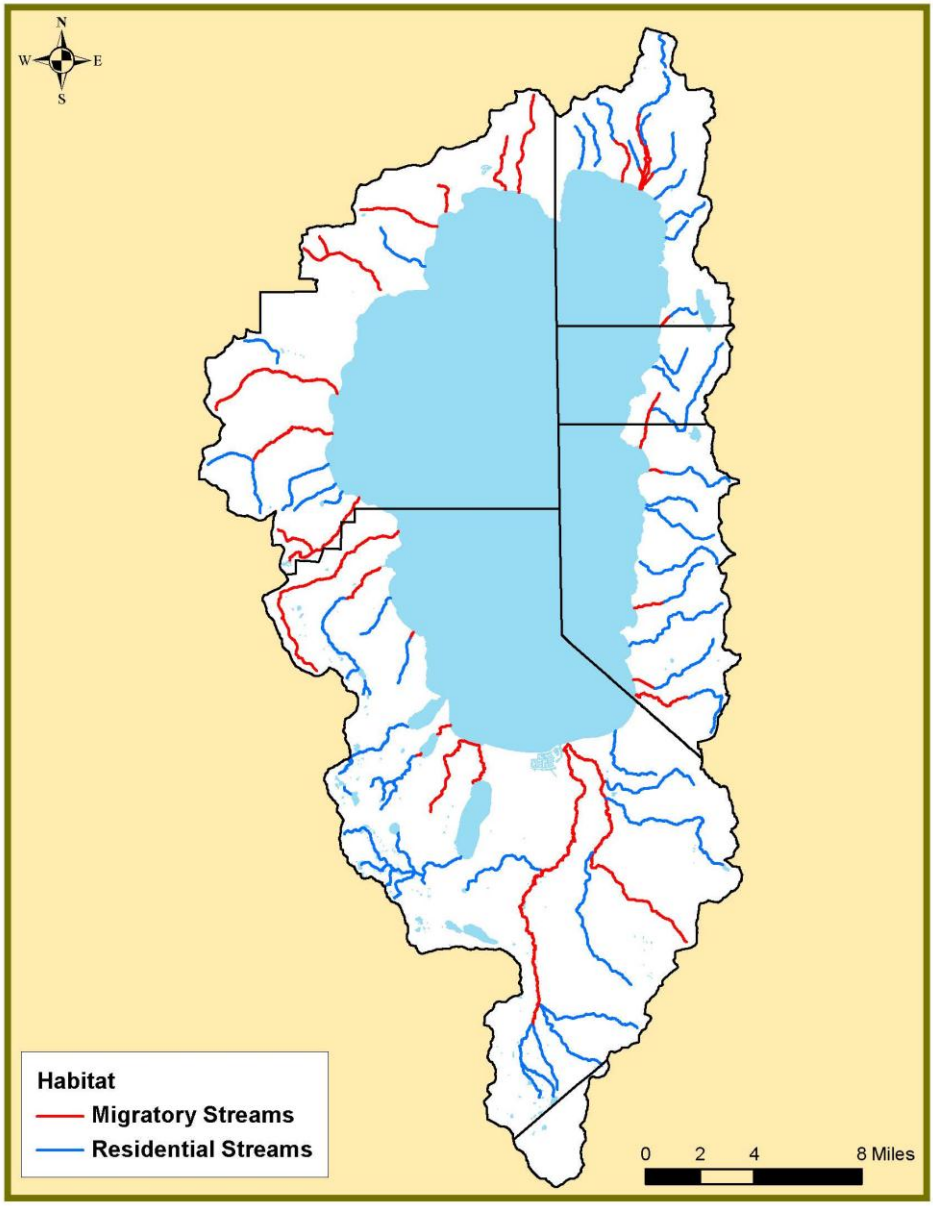
Stream systems are important aquatic resources. Streams are critical to the Lake Tahoe Basin's water cycle by feeding freshwater to lakes and ponds, recharging groundwater aquifers, providing habitats for a wide variety of aquatic and terrestrial organisms, and are corridors for fish and wildlife migration. TRPA refers to the area surrounding a stream as "Stream Environment Zones." Streams also play an important role in connecting fragmented habitats, and thus in conserving biodiversity.

To aid in conserving and enhancing stream habitat in the Region, TRPA has adopted policies and implements ordinances that limit the types of activities that occur in and adjacent to streams (TRPA 1986; TRPA 1987a as amended in 2012). TRPA administers a region-wide Environmental Improvement Program (EIP) that facilitates the stream restoration and enhancement on channel segments determined to be disturbed or impaired. Other actions, such as erosion control and stormwater treatment projects, implemented through the EIP are widely believed to also benefit stream habitat quality.

Stream habitats found in the Tahoe Region are similar to streams found throughout the Sierra Nevada. High elevation stream reaches are typically v-shaped channels bordered by deciduous and conifer vegetation. Streams at higher elevation typically contain cascades, riffles, runs and pools occasionally interspersed low gradient meadows. Stream bed substrates most common at high elevation reaches are composed of bolder, rocks, cobbles and gravels with smaller diameter sand and silt interspersed. Lower elevation stream reaches typically meander through low gradient flood plains and are typically bordered by willow and a variety meadow wildflowers, forbs, sedges and grasses. Streambed substrates in lower elevation stream reaches are typical of a deposition zone with sand and silt dominating.

In recognition of the importance of streams for Tahoe's fishery, TRPA adopted three Threshold Standards related to the Stream Habitat Indicator Reporting Category. The Stream Habitat Threshold Standard is a Numerical Standard to achieve 75 miles of "excellent," 105 miles of "good," and 38 miles of "marginal" stream habitat for streams classified as residential and migratory. According to Resolution 82-11 the standard can be evaluated based on "*re-rated stream scores set forth in Appendix C-1 of the 1996 Threshold Evaluation Report.*" Unfortunately, Appendix C-1 of the 1996 Threshold Evaluation does not provide any details on the field sampling methods used to collect stream habitat data or clear definitions of evaluation criteria. Consequently, the determination for stream habitat conditions based on this prescribed evaluation system is "unknown," because no data has been collected since the 1996 Threshold Evaluation to specifically assess the condition of streams as originally envisioned for the Threshold Standard adoption in 1982. However, TRPA, in partnership with Nevada Division of Environmental Protection, Lahontan Regional Water Quality Control Board, California Department of Fish and Game – Aquatic Bioassessment Lab, US Forest Service – Region 5, and Humboldt State University, initiated stream bioassessment efforts in the Lake Tahoe Basin starting in 2009. Data from 2009 and 2010 field sampling efforts following the California Surface Water Ambient Monitoring Protocol for wadeable streams is currently being analyzed by Humboldt State University to reveal region-wide stream habitat conditions. Excerpts of preliminary results from this analysis are included below in the Indicator Summary.

Stream Habitat: **Miles of Stream Habitat**

Reporting Icon	Map
MILES OF STREAM HABITAT Status: **Unknown** Trend: **Unknown** Confidence: **N/A**	 Map of streams in the Lake Tahoe Region designated by TRPA as residential or migratory (TRPA 1982a; TRPA GIS).

Data Evaluation and Interpretation

Relevance – Streams and their associated riparian habitats are key components of Lake Tahoe Basin's aquatic ecosystems and important to people. Concern for stream water quality and biological condition is embodied in various federal, state, and regional water quality laws, regulations, and ordinances, including the Clean Water Act, 208 Water Quality Plan, TRPA Code of Ordinances (1987 as amended in 2012), California and Nevada state water quality standards. Streams and associated environments significantly contribute to the Tahoe Basin's biological diversity and provide people with a place for recreation and reflection. Past Threshold Evaluations (1991 and 1996) of stream habitat quality used a list of subjective evaluation criteria and a rating system to judge and classify stream habitat conditions and included: stream flow, pool abundance, aquatic cover, substrate, shade canopy, aquatic

vegetation, benthic fauna, fish abundance, reproduction, bank/channel stability, stream gradient, barrier/obstructions, and percent diversions (TRPA 1996).

Threshold Category –Fisheries

Indicator Reporting Category – Stream Habitat

Adopted Standards – Maintain the 75 miles of excellent, 105 miles of good, and 38 miles of marginal stream habitat as indicated by the Stream Habitat Quality Overlay map, amended May 1997, based upon the re-rated stream scores set forth in Appendix C-1 of the 1996 Evaluation Report.

Type of Standard - Numerical

Indicator (unit of measure) – Miles of stream habitat in different condition classes (Miles - excellent, good and marginal)

Status – A determination of "unknown" is provided due to insufficient documentation of methods and definitions originally used to assess stream conditions (TRPA 1982a). Alternatively presented is the status of other stream habitat condition indicators. An analysis of benthic macroinvertebrate data (as indicators of water quality and as a food source for fish) found that the majority of sites sampled in the Tahoe Basin in 2009 and 2010 were in excellent or good condition. Approximately 56% (n=53) of samples from 2009 and 2010 were categorized as excellent, 19% (n=18) were categorized as good, 15% (n=14) as degraded, and 10% (n=10) as very degraded. Overall, the best conditions were detected on the west and north shores of Lake Tahoe, and higher elevations of the south shore. An association was found between levels of urban development and degraded riverine conditions, but there were also sites in areas of low urbanization with degraded conditions. Inventories of fish species composition in migratory and residential streams conducted by the US Forest Service between 2007 and 2010 indicated that the Tahoe Region currently supports a variety of non-game and game species that are native and non-native to Tahoe streams (USDA 2007; USDA 2008; USDA 2009a; USDA 2010a). A species that was frequently encountered during fish inventory efforts was Paiute sculpin (*Cottus beldingii*), a species that requires clear, cold water to persist, and are considered an indicator of healthy functioning stream systems (Moyle 2002). The frequent detection of this species (and several other native fish species) at several of the sample sites suggests that Tahoe's streams currently provide suitable habitat for native non-game fishes as well as non-native game fishes. An inventory of road crossings on lands managed by the US Forest Service-LTBMU found that 82% (50 of 61) of the road crossing with a complete assessment did not meet the criteria for fish passage and represented barriers for at least one life stage of salmonid or sculpin (Vacirca 2010). Only 11% of the fully assessed crossings met the passage criteria for juvenile and adult salmonid life stages. The remaining 7% of fully assessed crossings were "undetermined" for salmonid or sculpin species and were candidates for further evaluation.

Trend – Due to insufficient documentation of methods originally used to assess stream conditions, it is not possible to assess trends relative to adopted standards for Tahoe streams. Consequently, a determination of "unknown" is provided. An evaluation alternative stream habitat condition indicators suggests the following trend-related results. A study conducted by Fore (2007) examined benthic macroinvertebrate data collected in the Tahoe Basin in 2003. A comparison of RIVPACS results from that study with the results from the first two years of the TRPA monitoring program (2009-2010) provides the opportunity to look for trends in ecological condition over time. A scatter plot of O/E scores from sites sampled in nearby locations in both the earlier study (2003) plotted against the more recent study (2009-2010) revealed a general 1:1 relationship with an R^2 value of 0.58. One outlier to this agreement was found at General Creek, where the early data set placed it in excellent condition and the more recent sampling puts it as very degraded. This outlier is currently under investigation. Overall, it appears that the high quality sites improved over this time period, but the low quality sites worsened. Further analysis is needed to ascertain explanations of these trends.

Confidence – Overall, confidence in the status and trend cannot be determined because of insufficient documentation of methods originally used to assess stream conditions and the lack of associated data.

Interim Target – Due to insufficient documentation of methods and definitions originally used to assess stream conditions, it is not possible to assess current status and trends of stream habitat consistently with previous evaluations, and thus not possible to estimate an interim target.

Target Attainment Date - Due to insufficient documentation of methods and definitions originally used to assess stream conditions, it is not possible to assess current status and trends of stream habitat consistently with previous evaluations, and thus not possible to estimate a target attainment date.

Human and Environmental Drivers – Natural factors include weather and climate patterns and geological context such as geological origin, elevation, topography, and soils. Past resource extraction has contributed to legacy effects on the physical features of streams and their current biota. Channel modifications associated with historic logging activities (e.g., dams, water extraction and diversions, flumes, stream channelization, and flood control impoundments) altered stream channel structure and watershed-specific hydrology. Historic grazing damaged stream banks and soils, altered stream channel habitat structure through sedimentation, and simplified riparian plant structure and composition (USDA 2000). The intentional and unintentional introduction of non-native species alters biological features of streams. Unmitigated fuels-reduction activities have the potential to compact or otherwise damage soils, elevate sediment loads in streams, introduce non-native species, and alter stream hydrology. Road crossings can confine streams and change a streams fluvial geomorphology as well as create barriers to fish migration. Introduction of new plant species can modify stream habitats. Dams can create barriers to movement and migration of aquatic organisms, and alter natural stream flow patterns. Several factors within developed areas are believed to contribute to the alterations of key stream features including: 1) the urban

transportation infrastructure, 2) land cover and disturbance, 3) urban landscaping practices, and 4) water withdrawal and export. Roads can contribute sediment and chemical inputs, thereby altering streambed conditions and elevating chemical pollutant loads. Road crossings can confine streams from natural meander patterns, resulting in impediments to organism movements, stream bank instability, and channel downgrading. Increased impervious surfaces on the landscape can prevent water from naturally percolating into soils thereby affect its rate of delivery to streams. As a result, organisms downstream of developed areas can experience more intense flooding events and flashier flow regimes as the water moves faster from the land into the channel. Urban landscaping can affect the physical, biological, and chemical properties of streams by introducing non-native plants, elevating nutrients, toxics, and herbicide loads to streams.

Monitoring Approach – As stated, the originally conceived approach for determining stream habitat conditions has not been implemented since prior to 1996 due to lack of sufficient documentation of sampling and analysis protocols. Current and future stream condition assessments will follow a monitoring and evaluation plan (TRPA and Humboldt State University [in draft]) and use procedures outlined by Ode (2007). The analysis tool selected for interpretation of benthic macroinvertebrate data in the Tahoe Basin is the River Invertebrate Prediction and Classification System or RIVPACS (Hawkins et al. 2000). RIVPACS uses cluster analyses to separate reference sites into groupings based on biology, then predicts group membership based on physical variables unaffected by human stressors such as elevation, watershed area, slope, latitude, geology, temperature, and precipitation. Probabilities can then be generated for the likelihood of observing species given the stream's physical setting (Hawkins et al., 2000). The expected value (E) is based on both the taxa present and the probability of detection (how commonly found). Low ratios of observed to expected numbers of taxa (O/E) indicates degradation because it indicates that many of the species that were predicted to occur may have been lost as a result of anthropogenic disturbance. Procedures prescribed in Ode (2007) provide guidance on benthic macroinvertebrate (aquatic insects, snails, worms, crustaceans etc.) sampling and procedures for measuring instream and riparian habitats, and ambient water chemistry in conjunction with aquatic insect samples. Future evaluations of stream habitat conditions will use these procedures.

Monitoring Partners – US Forest Service, California Department of Fish and Game, Nevada Department of Wildlife, Nevada Division of Environmental Protection, Lahontan Water Quality Control Board and TRPA

Programs and Actions Implemented to Improve Conditions – TRPA and other agencies (e.g., Lahontan Regional Water Quality Control Board, California Department of Fish and Game, US Army Corps of Engineers) regulate projects and activities in the stream environment zones including activities in the stream itself. The Environmental Improvement Program has facilitated the implementation of numerous stream restoration projects that aim to restore legacy impacts to streams including reconfiguration of stream channels, improving road crossing for fish passage and other improvements to fish habitat (enhanced riparian vegetation cover).

Effectiveness of Programs and Actions – The current policies and ordinances seem appropriate due to their emphasis on the protection of fish habitat and the surrounding stream environment zone. The Environment Improvement Program's efforts to reverse legacy impacts to streams appear appropriate although there is a need to develop a consistent programmatic approach to measure the effectiveness of stream restoration projects.

Recommendation for Additional Actions – It is recommended the TRPA and basin partners continue efforts to enhance and restore stream habitat, include the implementation of projects that result in the reduction of impervious cover and treatment of urban stormwater. The existing approach to characterizing the status and trends of stream habitat condition is poorly documented making it infeasible to consistently re-assess stream conditions in the same way. Consequently, it is not possible to characterize current stream habitat conditions relative to adopted TRPA Threshold Standards and trend over time as originally conceived. New widely reviewed and accepted bioassessment approaches, which include sampling the benthic macroinvertebrate community and other stream habitat characteristics, have been developed and are currently being pilot-implemented in the Lake Tahoe Basin by TRPA and others (California Department of Fish and Game, Nevada Division of Environmental Protection, Lahontan Water Quality Control Board, Humboldt State University). Bioassessments are considered to be cost-effective and a good surrogate measure of actual fish habitat conditions (Karr and Chu 1999). Implementation of this pilot effort is being guided by standardized protocols developed and approved by State of California. Results of this pilot effort should be considered in amending the existing Threshold Standard for stream habitats. It is also recommended that stream restoration and investments in the control and prevention of aquatic invasive species be continued.

Instream Flow

Because of the similarities between the adopted Management Standard and Policy Statement for Instream Flow, the implementation status of both Threshold Standards is combined here.

Relevance: There are 63 tributaries that drain to Lake Tahoe, and one tributary that drains from the Basin. The amount of water flowing through a stream is primarily dependent on the size of its watershed and the amount of precipitation within a given year. Streams provide critical habitat to a diversity of native and non-native fish populations, including other riverine dependent organisms. Historic logging, grazing and land uses interrupted the hydrologic integrity of many of the streams and tributaries draining into Lake Tahoe, (USDA 2000) and the results of these legacy activities are evident today (Tracy and Rost 2003; Vacirca 2010). Alteration of streams flow regimes, such as water diversions, can result in adverse impacts to stream habitat diversity, function, and productivity of aquatic ecosystems and organisms (Karr and Chu 1999; Stephens et al. 2004). A component of the TRPA Regional Plan is to maintain a healthy functioning fishery through the conservation and restoration of natural flow regimes (TRPA 1986; TRPA 1987a as amended in 2012).

Threshold Category: Fisheries

Indicator Reporting Category: Instream Flow

Adopted Standards: There are two Threshold Standards adopted in Resolution 82-11 that address the conservation and restoration of instream flows. The Management Standard for instream flow states: "*Until instream flow standards are established in the Regional Plan to protect fishery values, a nondegradation standard shall apply to instream flows.*" The Policy Statement states, "*It shall be a policy of the TRPA Governing Board to seek transfers of existing points of water diversion from streams to Lake Tahoe.*" A review of TRPA (1982a) indicates that the standards were brought forward to address concern over the diversion of water from streams for consumptive uses, irrigation and snowmaking. It was believed at the time that the agency could prescribe minimum flow standards for each stream in the Basin in order to maintain a healthy fishery (TRPA 1982a).

Type of Standards: Management Standard and Policy Statement

Evaluation Criteria: Three evaluation criteria were evaluated to determine the implementation status of the Instream Flow Threshold Standards, including:

1. Has TRPA adopted appropriate policies, ordinances and/or programs to support the adopted Threshold Standards?
2. Has TRPA permitted or otherwise allowed for new permanent diversions or alteration of stream flows since 1987?
3. Does available scientific information support the need to adopt instream flow standards for Regional streams?

Attainment Status: Based on the evaluation criteria above, the Threshold Standards are determined to be "Implemented" and in attainment.

Criteria 1: TRPA and other agencies have instituted a number of regulatory actions and restoration projects that support the nondegradation Management Standard and Policy Statement set forth under the Instream Flow Indicator Reporting Category. TRPA regulates projects and activities that

have the potential to impact the integrity of stream habitat including impacts to stream flows in the Tahoe Region (see TRPA 1986 and TRPA 1987a as amended in 2012). In addition, other agencies have established rules that regulate the types of projects and activities that can occur in stream habitats (e.g., California Department of Fish and Game[1]). The US Forest Service-LTBMU and other agencies, such as the California Tahoe Conservancy have implemented (or are planning) several large-scale stream restoration projects at Cook House Meadow, Big Meadow Creek, Blackwood Creek, Cold Creek, Angora Creek, Trout Creek and Meeks Creek, as well as the Upper Truckee River. One of the main objectives of these projects is (to the extent practical) to return streams to a natural flow regime (Vacirca 2010).

Criteria 2: A review of available TRPA permit data indicates that TRPA has only permitted temporary stream flow diversion/alterations with the ultimate project objective of stream enhancement and/or restoration. In no instance were permit records found indicating that TRPA permitted new permanent diversion or the extraction of water from Tahoe Regional streams for consumptive uses. There are at least four dams in the Region that actively regulate stream flow under historic water rights and these include: Echo Creek (at Lower Echo Lake), Taylor Creek (at Fallen Leaf Lake), Truckee River at the Lake Tahoe outlet, and Marlette Creek at Marlette Lake outlet. Of these dams, only Echo Lake dam operation diverts stream flow from the Lake Tahoe Basin as a backup to El Dorado Irrigation District's water system during drought conditions; in normal water years, no water is diverted from Echo Lake. Each dam is required to provide minimum stream flows necessary to support stream fisheries values as a component of their operating agreements with state and federal regulatory and fisheries management agencies. According to Madonna Dunbar (Tahoe Water Suppliers Association, personal conversation, 2011), waters for consumptive use in the Tahoe Region are primarily sourced from lake intakes (54%) or from groundwater sources (46%), and less than 1% is drawn from other sources such as springs or streams.

Criteria 3: The Desert Research Institute (Tracy and Rost 2003) completed the following tasks to assist TRPA in understanding stream flow conditions consistent with the direction provided in the instream flow Management Standard:

1. Conduct a statistical analysis of stream flow rates for tributaries with continuous flow gaging records;
2. Develop a statistical model to predict daily stream flow rates of tributaries with little or no gaging records;
3. Develop a statistical model to predict instream flow needs for salmonid (trout) species in Lake Tahoe's streams; and
4. Conduct a field survey to locate and assess the level of anthropogenic disturbance to the hydrology of Lake Tahoe's streams.

This study developed statistical relationships for gaged (i.e., monitored) and ungaged tributaries in the Lake Tahoe Basin to describe their daily flow-exceedence-frequency relationships for each month of the year. These relationships were then compared to published 'optimal' instream flow rates for trout species for several of TRPA's listed threshold tributaries. Comparisons indicated that only a limited number of streams meet defined 'optimal' instream flow requirements (Snider et al. 1987). Trout Creek and Upper Truckee River showed the greatest potential for meeting 'optimal' instream flow rates for both trout-rearing and spawning periods. It was recognized that a much

[1] ***California Fish and Game Code – Section 1600-1616;*** *http://www.leginfo.ca.gov/cgi-bin/displaycode?section=fgc&group=01001-02000&file=1600-1616;*

larger proportion of streams provide 'suitable' stream flow for trout species as opposed to 'optimal' and that the maintenance of unrestricted stream flows, regardless of flow rates, are important to other aquatic dependent organisms, such as invertebrates, native fishes, amphibians and some reptiles. Tracy and Rost's (2003) analysis also suggested that instream flow rates could be extrapolated to a larger number of tributaries within the Basin based on the tributary's physical characteristics. Finally, a field assessment of Lake Tahoe's "threshold" tributaries showed that about 50% of the tributaries have some type of man-induced disturbance (e.g., impoundment, non-functional earthen dams, artificial stream bank stabilization) that could potentially affect their hydrologic characteristics as well as limit an organism's ability to move within the stream corridor. However, Tracy and Rost (2003) found that the effect of the majority of man-induced disturbances on stream flow of was relatively small, and would likely only affect the tributary's hydrologic characteristics periodically during very low flow conditions experienced during droughts.

Tracy and Rost (2003) found that the flow of the vast majority of streams in the Tahoe Region is primarily regulated by the amount of precipitation occurring within the watershed. Their assessment of stream flow conditions stopped short of recommending minimum flow standards for streams, largely because only two streams have a high probability to provide 'optimal' flow conditions and because minimum flow requirements would be different for different fish species. Other recommendations were made including:

- If improving flow conditions for non-native trout fish is the goal, land management agencies should prioritize restoration in Trout Creek and Upper Truckee River. These two watersheds have been and continue to be the focus of EIP stream restoration projects.
- Although there were a number of human created stream flow impediments (50% of "Threshold" streams have at least one impediment), their effect on stream flow characteristics was negligible. Thus, removal of structures would only marginally improve hydrologic conditions, but would likely improve stream corridor mobility for aquatic organisms during very low stream flow conditions.
- Methodologies for determining instream flow requirements for all of Tahoe Basin's fish species would need to be developed in order to inform scientifically supported minimum flow standards for different streams. At the current time, no published studies could be found that identified instream flow needs for Tahoe's native non-game species. These species are an important element of the Basin's aquatic ecology, and understanding their habitat needs should be placed on equal footing with those of introduced trout species that have been the focus of previous studies within the Basin.

Based on Tracy and Rost's (2003) evaluation, it appears that TRPA's original recommendation to establish minimum instream flow conditions could be extremely costly (e.g., research to establish minimum flow requirements for each species), with little if any additional benefit to the fishery. Their finding that stream flow is primarily driven by within-watershed precipitation (which cannot be regulated by TRPA), and that TRPA's existing regulations restrict projects or activities from permanently diverting or impacting flow from streams, suggests that the need to establish minimum flow standards for individual streams is unwarranted. It is recognized however, that measures of stream flow be integrated into stream habitat monitoring protocols as a variable to help explain drivers of stream habitat conditions.

Human & Environmental Drivers: Weather and climate patterns and geological context such as elevation and topography significantly affect stream flow characteristics. Historic channel

modifications associated with historic logging activities and land uses (e.g., dams, water extraction and within-watershed diversions, urban development and infrastructure, flumes, stream channelization, and flood control impoundments) that preceded the 1987 Regional Plan altered stream channel structure and watershed-specific hydrology.

Programs and Actions Implemented to Improve Conditions: As stated in Evaluation Criteria 1 (above), TRPA and other agencies with jurisdictional authority regulate projects that could interfere with the health of fish populations within the Lake Tahoe Basin. TRPA has instituted a number of actions that underscore the nondegradation policy set forth under the Instream Flow threshold requirements. These actions include restrictions on stream zone encroachment and the facilitation of the EIP watershed restoration program. Overall, TRPA has only permitted stream flow alteration actions with the ultimate objective of improving and restoring natural hydrology, and has cooperated with partner agencies with like aims. The U.S. Forest Service, Lake Tahoe Basin Management Unit and other land management agencies have implemented and continue to plan several large-scale stream restoration projects.

Effectiveness of Programs and Actions: Based on the evaluation criteria presented, TRPA and other agencies have been effective at averting new permanent flow diversions from streams in the Lake Tahoe Basin since 1987. Diversions of streams for consumptive water use are extremely limited as the majority of water used comes from either lake or groundwater sources.

Recommendation for Additional Actions: Current TRPA policies and regulations on limiting new permanent stream flow diversion appears appropriate and should be maintained. Likewise, EIP stream restoration efforts, especially projects focused on restoring natural hydrology and improving stream corridor connectivity should continue to be supported by TRPA as they are addressing legacy impacts to stream systems. Based on Tracy and Rost's (2003) assessment, the direction to establish minimum instream flow standards for Regional streams appears unnecessary because it would result in little if any benefit to fishery resources. Minimum flow standards should be assigned through the permitting process on a case-by-case basis, as the agency has no ability to regulate natural precipitation. The Threshold Standards for instream flow should be revised or amended as appropriate to reflect this finding.

Lahontan Cutthroat Trout

Relevance: The Lahontan cutthroat trout (LCT, *Oncrhynchus clarkii henshawi*), the only native trout in the Lake Tahoe Basin, was once a top predator in Lake Tahoe's aquatic ecosystem. Due to overfishing, habitat degradation, and the introduction of non-native aquatic species it was extirpated in the 1930s from Lake Tahoe Basin (Allen et al. 2003). It is currently listed as a 'threatened species' under the Federal Endangered Species Act (as amended).

Evaluation Criteria: Two evaluation criteria were evaluated to determine the implementation status of the Lahontan Cutthroat Trout Policy Statement, including:

1. Has TRPA adopted appropriate policies, ordinances and/or programs to support the adopted Threshold Standard?
2. Is there evidence to suggest that at least one self-sustaining population of Lahontan cutthroat trout has been established in the Lake Tahoe Region?

Criteria 1: Restoration efforts are underway to restore the native LCT population into their historic lacustrine (lake) and fluvial (stream) habitats throughout the Truckee River Basin including the Tahoe Basin (Figure 7-1) (TRPA 2007a; TRPA 2010). In April 2007, TRPA joined the Tahoe Basin Recovery Implementation Team (TBRIT), which was formed as part of the on-going efforts to develop and implement actions to help recover LCT. The role of TRPA in the TBRIT is one of support; TRPA does not manage LCT but rather serves to protect and restore the habitat through policy, regulation and support of reintroduction efforts (see Chapter 64 of TRPA Code of Ordinances).

Criteria 2: Lahontan cutthroat trout was reintroduced by the California Department of Fish and Game into the headwaters of the Upper Truckee River near Meiss Meadows in 1989 and 1990. Through years of population management and monitoring, the Meiss Meadows population has become established as the only self-sustaining population of LCT in the Lake Tahoe Basin (Moore and Santora 2010). Since 2002, the U.S. Fish and Wildlife Service introduced the species to Fallen Leaf Lake, as a pilot effort to learn what conditions are necessary for successful restoration of the LCT in a lake environment. Initial findings suggest that adverse interactions with non-native species, including predation by lake trout (*Salvelinus namaycush*), hybridization with rainbow trout (*Oncorhynchus mykiss*), change in the food web, and competition for resources may pose a challenge to the reintroduction of LCT into lakes where non-native species are present (Vander Zanden et al. 2003). Overall, findings suggest that a viable LCT population may be possible if LCT can establish a niche apart from other trout species. Nascent efforts toward reintroducing LCT into Lake Tahoe itself, for recreational purposes, began during the summer months of 2011. The Nevada Department of Wildlife stocked approximately 22,000 LCT in Lake Tahoe as part of their efforts to begin stocking native aquatic species for the benefit of anglers. Additional research is needed to improve our understanding of reintroduced LCT population dynamics and their interactions with non-native species (Al-Chokhachy et al. 2009).

Status: The Lahontan cutthroat trout Policy Statement has been "implemented" by TRPA and determined to be in "attainment" with the adopted Policy Statement. The Region could further be considered in "attainment" because a population of LCT has been established in the Upper Truckee River with additional restoration efforts underway to re-establish populations in Lake Tahoe and Fallen Leaf Lake.

Recommendation for Additional Actions: Continue existing policies and ordinances in support of improving habitat conditions for native species. Continue to support other agencies' efforts to reintroduce Lahontan cutthroat trout where appropriate and as supported by best available information. Considering that sufficient policies and ordinances have been incorporated into the *TRPA Regional Plan,* it recommended that this Policy Statement be removed from list of adopted Threshold Standard or replaced with a Numerical Standard that can be objectively evaluated.

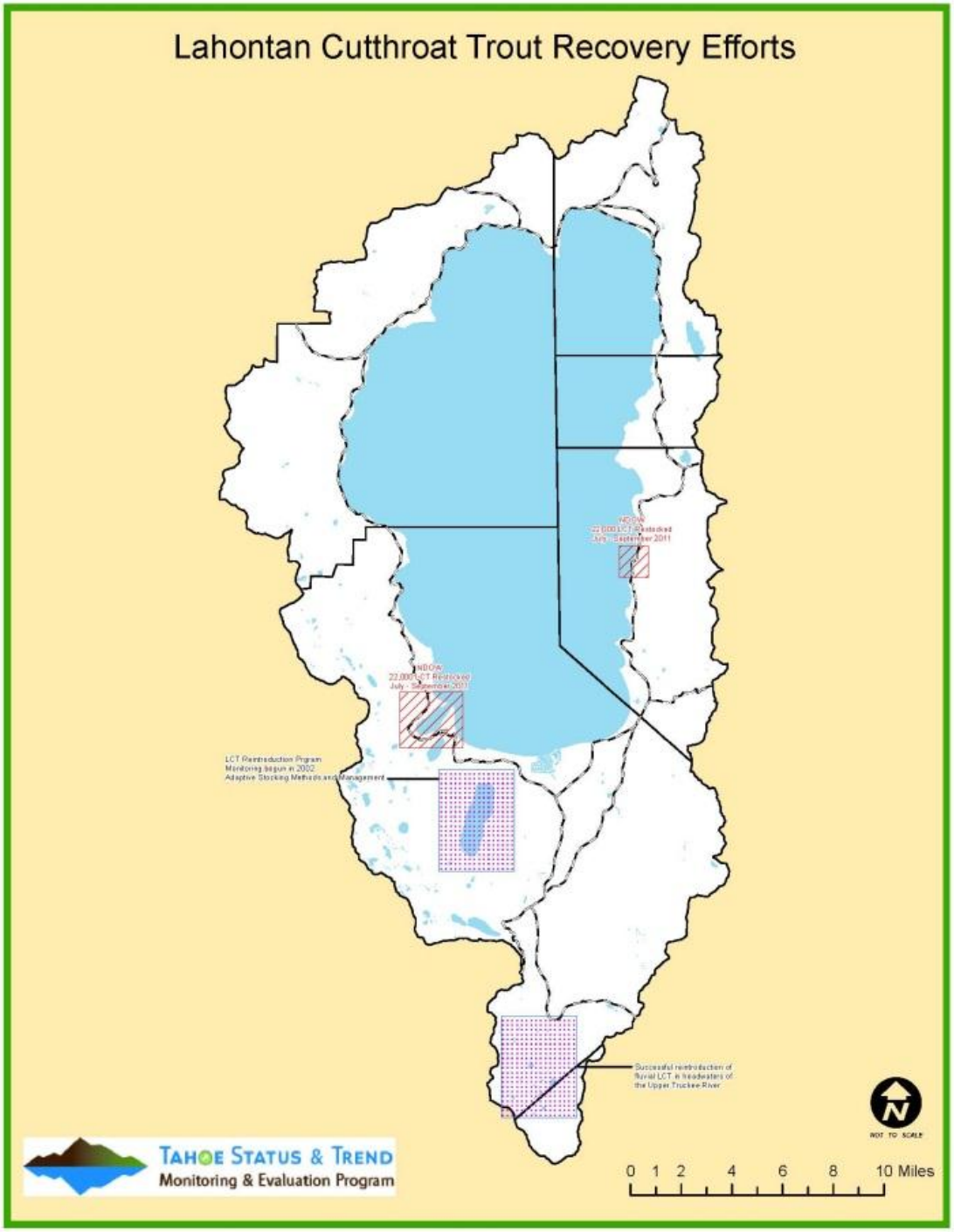


Figure 7-1. *Generalized locations of Lahontan cutthroat trout reintroduction efforts in the Lake Tahoe Region, 1989-2010.*